(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
5 July 2001 (05.07.2001)

PCT

(10) International Publication Number
WO 01/48419 A1

(51) International Patent Classification[7]: F17B 1/14, B01D 5/00

(21) International Application Number: PCT/NO00/00440

(22) International Filing Date:
21 December 2000 (21.12.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

19996471	23 December 1999 (23.12.1999)	NO
60/171,646	27 December 1999 (27.12.1999)	US

(71) Applicant *(for all designated States except US)*: IDE TIL PRODUKT AS [NO/NO]; P.O. Box 1101, N-4683 Sögne (NO).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: MÜLLER, Odd, G. [NO/NO]; Per Hanssonsvei 5D, N-4950 Risör (NO).

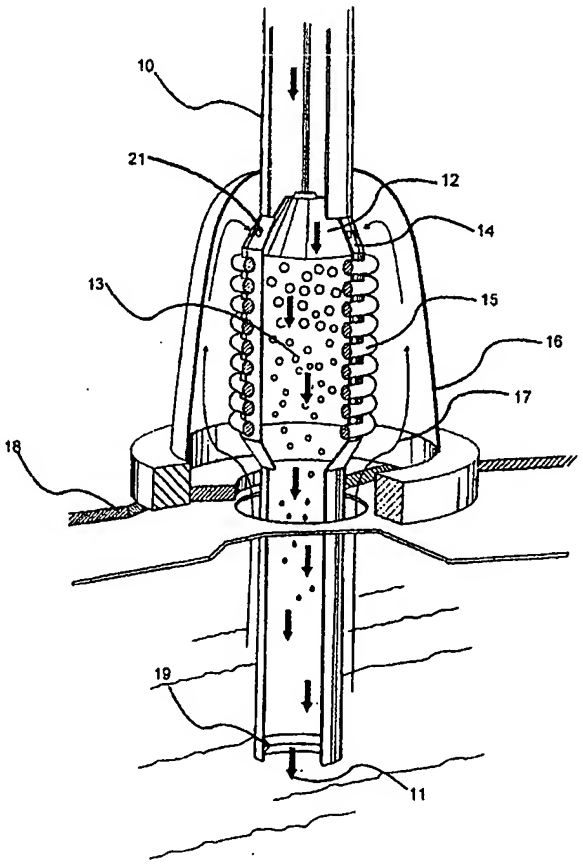
(74) Agent: BRYN & AARFLOT AS; P.O.Box 449 Sentrum, N-0104 Oslo (NO).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: METHOD, APPARATUS AND SYSTEM FOR THE CONDENSATION OF VAPOURS AND GASES



(57) Abstract: The invention concerns a method for the condensation of fumes or gases from a tank containing a liquid. The method comprises leading the liquid into a venturi to create a low pressure at the venturi.Ports are provided in the venturi at the area with low pressure and gas/vapour is lead to the ports in the venturi in the area with low pressure in such a way that the liquid entrains the gas/vapour and forms a fluid, such that the velocity is reduced and the pressure increased to condensate the gas/vapour. The fluid is then led from the chamber to a lower part of the tank for further condensation due to the hydrostatic pressure. An apparatus, a system and a use are also described.

WO 01/48419 A1

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Method, apparatus and system for the condensation of vapours and gases.

The present invention concerns a method, an apparatus and a system for the condensation of gases/fumes/vapours and particularly an apparatus for condensation of fumes during filling and storage of liquid fluids.

During storage and filling of fluids in tanks or vessels there is a problem that fumes or gases escapes from the handled or stored liquid. This is particularly prominent with volatile liquids and cooled, liquid gases. These gases or fumes have traditionally been allowed to escape into the atmosphere. This has lead to loss of fluid, pollution, and poor working conditions for people in the area. Examples of such liquids are crude oil, liquid natural gas (LNG) and other hydrocarbons.

Volatile liquids begin to produce fumes or gases during storage, and this creates a pressure build up in a tank where the liquid is stored. This pressure must be vented or bled off if it exceeds a certain value to avoid excessive loads on the tank where the liquid is stored.

Liquid will displace the gases or fumes contained in a tank during filling, and these gases must be vented or bled off to prevent pressure build up in the tank.

Various solutions to these problems have been previously suggested, and the solutions have comprised various complicated suction and condensation devices. Similar devices have particularly been used in connection with storage and transport of liquid gases. Examples are shown in the publications described below.

Norwegian Patent No. 305525 shows a "Method and apparatus for transport and storage of liquidised natural gas" Boil off is takes from a tank, and condensates in a condensation device with a cooler, and is led back into the tank. The device separates methane and nitrogen, and the nitrogen is vented into the atmosphere.

U.S. Patent 2,784,560, shows a "Process and apparatus for storage and shipping of liquefied gases" Boil off from the liquid gas is circulated in a device with a cooler, and is cooled by means of another liquid gas, to condensate the boil off and lead this back into the bottom of the tank.

U.S. Patent 3,733,838 shows a "System for reliquefying boil off vapour from liquefied gas". The system comprises an insulated storage tank, a venturi, a pump, and a heat exchanger. The system is intended used in connection with storage of liquid gas. A part of the liquid gas is compressed, and is expanded in a heat exchanger to provide cooling. The storage tank is cooled by expansion of a partly condensed stream that is led into the part of the tank, containing vapour.

U.S. Patent 3,921,412 shows a "Vapour recovery apparatus employing dispensing nozzle with condensing capacity". The nozzle is placed in a filler opening, and cools vapour/gas flowing out during filling, to condense the vapour, and let it drip back into the tank.

With the exception of this, the publications concern quite comprehensive systems for storage of cooled liquefied gas. None of these publications seeks to solve problems relating to shipping and storage of volatile liquids on a larger scale. In addition, it is known various suction devices that suck the vapour/gas from a tank to be filled, condenses the vapour/gas, and leads the condensate back to the tank the liquid comes from.

Accordingly, the present invention concerns a method for the condensation of vapours or gases from a tank containing a liquid, the method comprising the steps of:
Leading a fluid into a venturi to create a low pressure by the venturi, providing ports in the venturi in the area with low pressure, leading vapour/gas to the ports in the venturi in such a way that the liquid entrains the vapour/gas to form a fluid, leading the fluid with vapour/gas into a chamber in such a way that the velocity is reduced, and the pressure increases for the condensation of the vapour/gas, and leading the fluid from the chamber to the lowermost part of the tank for further condensation due to the hydrostatic pressure.

Furthermore, the invention comprises an apparatus for the condensation of vapour or gas coming from one or several tanks for storage of liquid when filling or storing the liquid in the tank or tanks, the apparatus comprising a supply channel for the supply of liquid to the apparatus, and a housing for collecting and leading the gas/vapour to be condensed, a venturi with induction ports for entraining the vapour/gas into the liquid, a chamber for the condensation of the gas/vapour at a higher pressure, one or several gas induction ports for the transfer of the gas/vapour to the tank or tanks to the housing, and an outlet duct for transfer of liquid and gas/vapour to the tank/tanks, where the supply duct goes into the venturi with induction port that continues into the chamber, and then to the outlet duct that ends up in the tank or tanks, and where the housing encase the end of the supply duct ,the venturi with induction ports, and the chamber, such that the transition between the supply duct and the housing is sealed , and that the gas induction port is connected to the tank are tanks and the housing, such that the housing or the tanks are in a in a gas stream communication.

Below is a point-by-point description of a suction- and-condensation unit for treating unwanted evapouration from volatile fluids. In this connection, volatile fluids means a fluid that comprises several fractions with different boiling point and vapour pressure, so that the evapouration occurs at the ambient pressures and temperatures, such as petrol, crude oil and condensate.

When storing volatile liquids, it will be created a pressure in the tank or tanks where the liquid is stored. This pressure will, according to the invention, be reduced by pumping out liquid from the tank by means of a pump. This liquid is then lead through a piping system or the like, to the condensation apparatus. Inside the condensation apparatus, the liquid goes into a venturi to create a lower pressure inside the venturi, compared to the ambient pressure in the tank. The venturi comprises one or several ports or openings where the above lower pressure is created. The venturi may comprise means for varying the venturi effect of the flow rate to optimise the parameters under all conditions. These means may incorporate a tapered piston that may serve as an adjustable nozzle or valve in the venturi. The condensation apparatus is in connection with the gas/vapour between the liquid surface and the top of the tank. The gas/vapour will

thereby be able to pass from the space between the liquid surface and the top of the tank, and to the venturi device with ports in such a way that the vapour/gas is drawn through the ports or openings in the venturi device, ant into the circulating liquid. The liquid, now containing gas/vapour bobbles or cavities then precedes into a chamber where the gas/ vapour bubbles gets a reduced velocity, and thereby a higher pressure. This pressure, contributes to condensate the gas/vapour. This condensation may, if needed, be increased by means of a cooling element. From the chamber, the liquid is led in an outlet duct ending up at the bottom of the tank, where the hydrostatic pressure contributes to further condensation. Condensation of this kind is called "bubble condensation". The outlet duct may comprise one or several constrictions to control the pressures to achieve the best possible condensation. This constriction may, if desired, be variable. Possibly, other means, such as a proportional valve, is used to control these pressures.

When filling the tank, the above mention pump will be stopped, and a valve, piping system will bypass the pump and let the liquid that is filled go through the condensation apparatus.

Alternatively, the tank or tanks may comprise one or several condensation – and circulation devices, and the filler devices comprise a separate condensation unit. The number and size of the condensation apparatuses, will depend of the necessary capacity, that furthermore will depend on the size and shape of the tanks, the climate when the tank/tanks are situated, the nature of the fluid to be stored, how long the fluid is to be stored, flow rate when filling, etc.

Below is a short description of the figures.

Fig. 1 shows section in perspective of the condensation apparatus according to the invention,

fig. 2 shows a section from the side of the condensation apparatus of fig 1.,

fig. 3 shows a perspective view of a system according to the invention,

fig 4 shows an elevation view of the system on fig 1 and

fig 5 shows a tanker being filled with liquid, with the apparatus in use.

Below is an embodiment of the invention with reference to the enclosed drawings.

Fig 1 and 2 shows a condensation apparatus according to the invention. The apparatus is connected to a tube or pipeline 10 for the filling of liquid. A conical piston 12 is attached to the end of the tube or pipeline. The purpose of this is to make a narrow cross section with high liquid velocity in the intersection between the tube 10 and the conical intersection 14 in the tube. The increase in velocity of the liquid flow creates a reduction of pressure. With the correct calibration, this pressure reduction is sufficient to draw the surrounding gas through small port 21 in the conical intersection 14. The support of the conical piston 12 is made such that the cross section area can be adjusted depending of the liquid flow rate, to achieve the desired under pressure compared to the ambient conditions. In a chamber 13, after the conical expansion, of the tube 10, with a venturi suction of gas/vapour, a reduced velocity results in to an increase of pressure such that the gas bubbles created when the gas was sucked into the liquid, can condensate if the thermodynamic parameters are correct. The potential for the condensation is governed by thermodynamic equilibrium. Te condensation efficiency is dependent on bubble size and turbulence intensity. Small bubbles and much turbulence increase the condensation speed.

The tube in the conical transition 14 is expanded between tube or pipeline, and the condensation apparatus.

A ring of small ports 21, that the surrounding gas is sucked through, is placed on this conical transition. In cases where the thermodynamic equilibrium indicates that the potential for bubble condensation is not sufficient, this potential can be increased; cooling the gas with a cooling element 15 can increase this potential. The location of the cooling element may be as shown on the figure, or inside the bubble chamber 13 such that it gets an optimum contact with the gas bubbles. A third, more energy-consuming alternative, is cooling of the liquid flow.

To suck vapour that is displaced from the tank when filling into the condensation apparatus, it is equipped with a "gas hood" 16 that forms an as sealed chamber as possible between the filler opening in the tank and the ports 21 in the conical cross section where the gas is sucked into the bubble chamber. Inside the gas hood 16, a room 17 is leading displaced vapour from tank 19 to the condensation apparatus. The condensation apparatus is installed in the top of the tank or the deck of a ship 18 The restriction

19 increases the pressure in those cases where it can increase the potential for condensation in the fluid flow 11.

The figures 3 and 4 show a system where the condensation apparatus on fig 1 and 2 is used. The system is intended or use during storage and transport, and is run by letting oil being circulated in a loop with suction from the top of the surface of the oil, through the condensation apparatus, and down through a long tube to the bottom of the tank. The oil may be collected at the top by the oil surface, and is filled to the bottom of the tank. The bottom of the tank has a greater pressure (hydrostatic) that allows a greater amount of volatile fractions to be at equilibrium as a liquid.

The flange 1 is connected to a conductor when filling or emptying. The valve 2 is opened when emptying and circulating in the loop for the condensation of oil vapour through the condensation apparatus 4. Pump 5 circulates the oil during transport, and may be used for filling the oil tank 7. The condensation apparatus 4 may be placed on the ship deck or on the oil tank 7. The pipe 8 leads the oil to the bottom of the tank 7. The valve 9 closes between the t-pipe and the condensation apparatus during filling.

Patent Claims :

1. A method for the condensation of fumes or gases from a tank containing a liquid comprising the steps of:
leading the liquid into a venturi to create a low pressure at the venturi;
providing ports in the venturi at the area with low pressure;
leading gas/vapour to the ports in the venturi in the area with low pressure in such a way that the liquid entrains the gas/vapour and forms a fluid;
leading the fluid with gas/vapour into a chamber such that the velocity is reduced and the pressure increases to condensate the gas/vapour.

2. The method according to claim 1 wherein the method further includes cooling of the fluid with a cooling element.

3. The method according to claim 1 wherein the method further includes regulating the pressure over the venturi by means of a variable venturi.

4. An apparatus for condensing vapours or gases coming from one or several tanks, for storage of liquid during shipping or storing of the liquid in the tank or tanks, where the apparatus comprises a supply duct 10 for supplying the fluid to the apparatus, wherein a housing 16 for the collection and leading of the gas/vapour to be condensed, a chamber 13 for condensing the gas/vapour at a higher pressure, one or several gas inlet ports for the transfer of the gas/vapour to the tank or tanks, to the housing 6, and a outlet pipe for the transfer of liquid and gas/vapour to the tank, where the supply duct 10 goes into the venturi, with inlet openings, 14 that further goes into the chamber 13, and then into the outlet duct, that further goes into the tank, or tanks and where the housing 16 encloses the venturi with inlet ports 14, such that the transition between the supply duct and the housing is sealed and that the gas inlet ports connected to the tank or tanks and the housing 16, such that the housing 16 and the tanks are communicating for transferral of gas/vapour .

5. The apparatus according to claim 4 wherein the venturi 14 comprises a variable nozzle 12 to control the pressures over the venturi 14.

6. The apparatus according to claim 4 wherein parts of the apparatus is cooled by means of one of, a cooling element, several cooling elements.

7. The apparatus according to claim 4 wherein the outlet duct comprises a restriction 19 to create a certain backpressure.

8. The apparatus according to claim 7 wherein the restriction 19 is variable to control the backpressure in the outlet duct.

9. The apparatus according to claim 4 wherein the apparatus furthermore comprises a pump for the circulation of liquid from one of the tank and tanks, through the housing with a venturi, and back into the tank.

10. A system for the condensation if gases created during storage of liquid wherein the system comprises: a tank or tanks, the condensation device of claim 4, and a pump for the circulation of the fluid from one of, the tank and tanks, through the condensation apparatus, and back into the tank.

11. The system for the condensation if gases created during storage of liquid according to claim 6 wherein the liquid that is circulated is pumped up to the surface of the liquid, and is led back at the bottom of the fluid.

12. Use of the apparatus according to claim 4 on a tanker vessel.

13. Use of the apparatus according to claim 4 on a tanker vehicle.

14. Use of the apparatus according to claim 4 on a storage plant.

15. Method according to any of the preceding claims wherein the liquid is hydrocarbons

16. Method according to claim 15 wherein the liquid is crude oil.

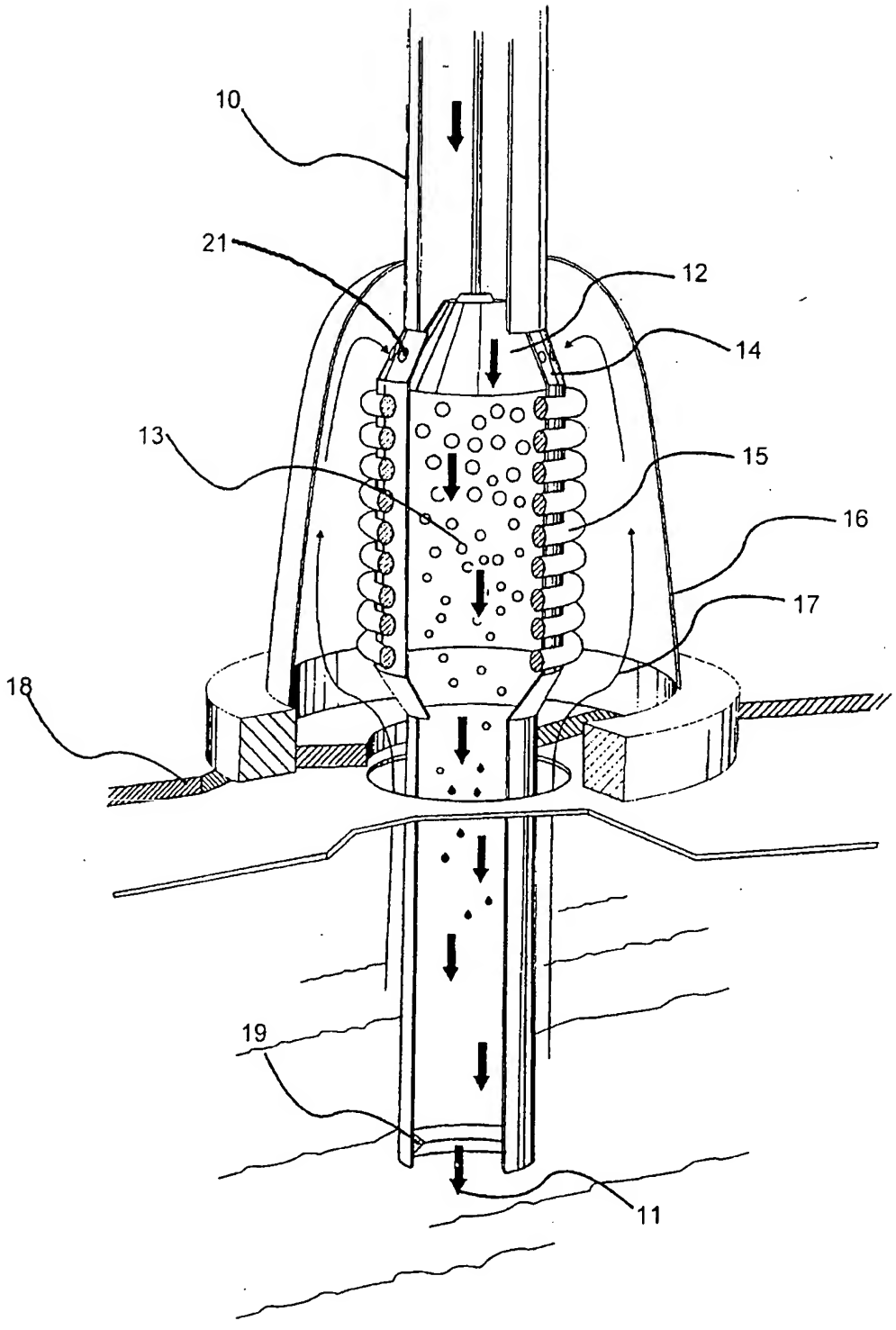


FIG. 1

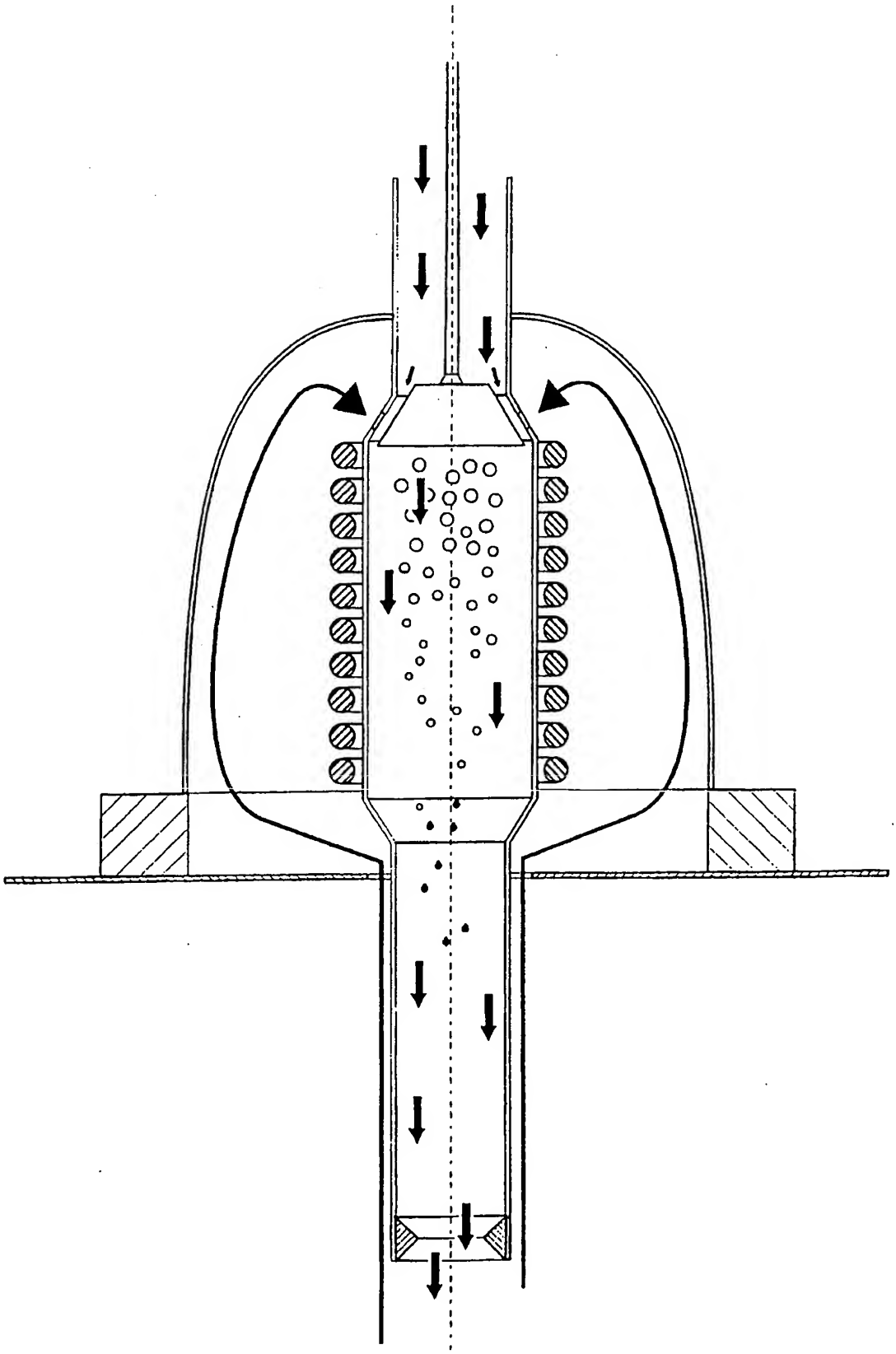


FIG. 2

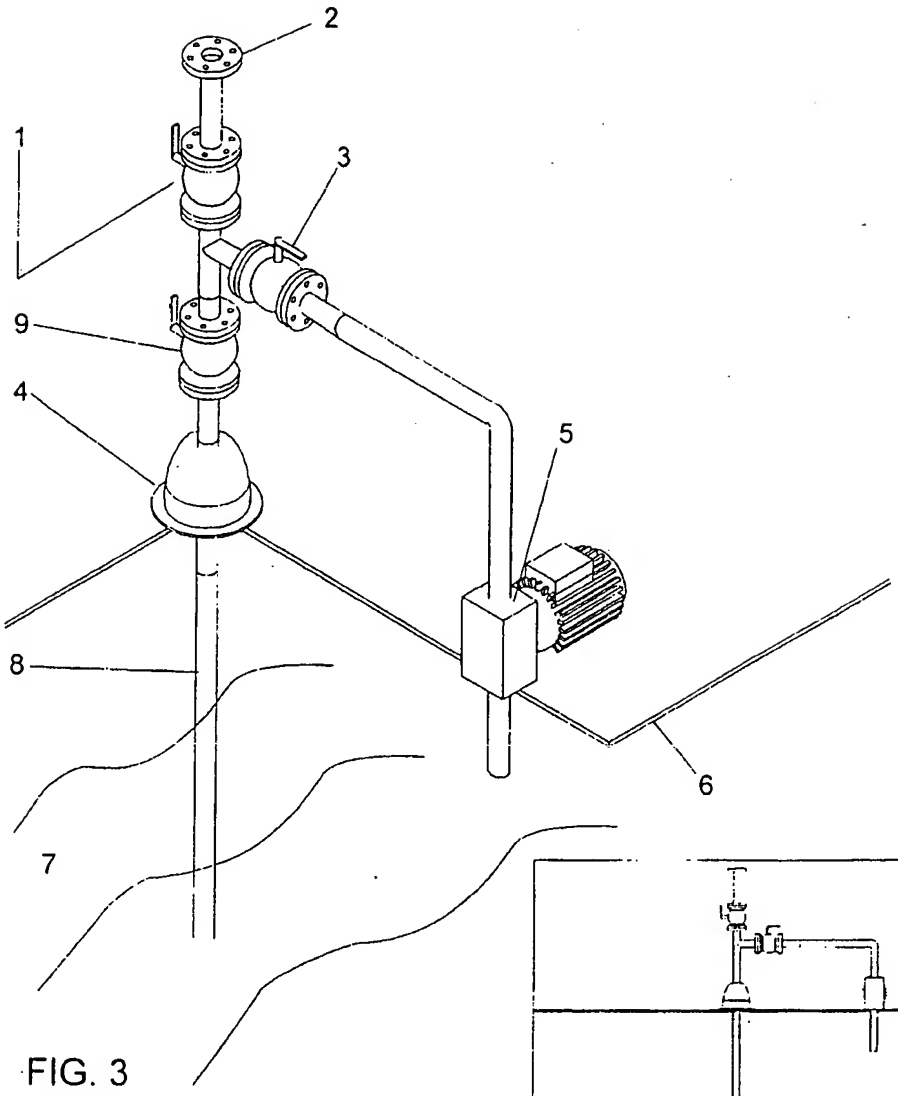


FIG. 3

FIG. 4

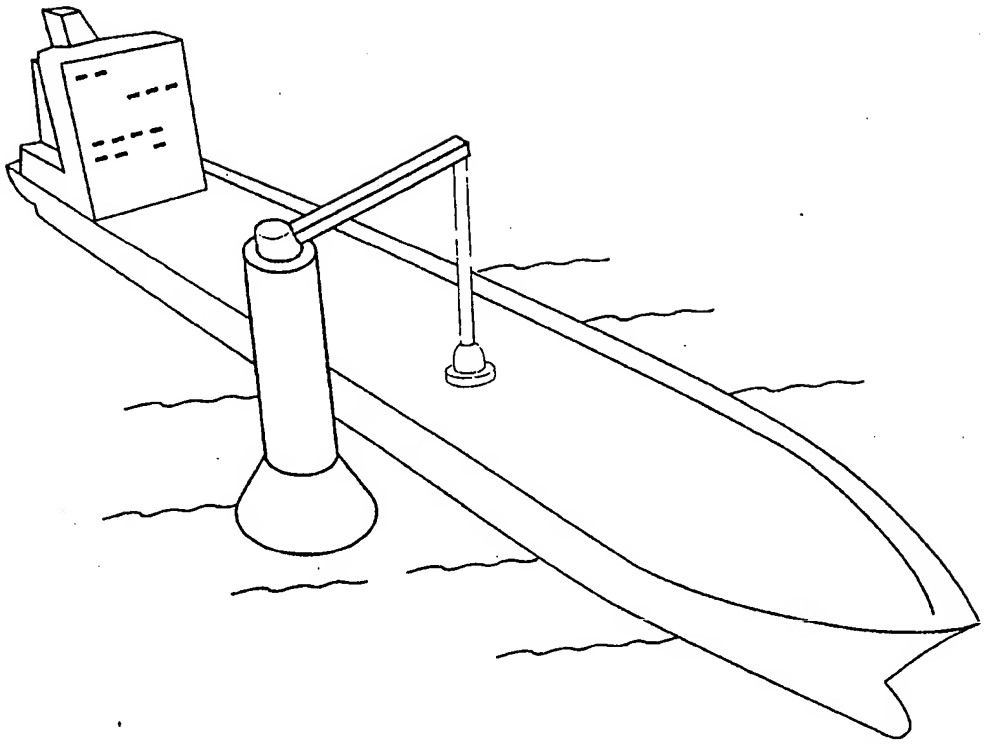


FIG. 5